

Management of Fractures of the Humerus in Ancient Egypt, Greece, and Rome

An Historical Review

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Abstract Fractures of the humerus have challenged medical practitioners since the beginning of recorded medical history. In the earliest known surgical text, *The Edwin Smith Papyrus* (copied circa 1600 BC), three cases of humeral fractures were described. Reduction by traction followed by bandaging with linen was recommended. In *Corpus Hippocraticum* (circa 440–340 BC), the maneuver of reduction was fully described: bandages of linen soaked in cerate and oil were applied followed by splinting after a week. In *The Alexandrian School of Medicine* (third century BC), shoulder dislocations complicated with fractures of the humerus were mentioned and the author discussed whether the dislocation should be reduced before or after the fracture. Celsus (25 BC–AD 50) distinguished shaft fractures from proximal and distal humeral fractures. He described different fracture patterns, including transverse, oblique, and multifragmented fractures. In Late Antiquity, complications from powerful traction or tight bandaging were described by Paul of Aegina (circa AD 625–690). Illustrations from sixteenth and seventeenth century surgical texts are included to show the ancient methods of reduction and bandaging. The richness of written sources points toward a multifaceted approach to the diagnosis,

reduction, and bandaging of humeral fracture in Ancient Egypt, Greece, and Rome.

Introduction

Management of fractures of the humerus has been discussed in surgical texts for more than three millennia. The recommended techniques for reduction followed by bandaging and splinting remained remarkably unchanged until the late nineteenth century when the introduction of anesthesia and radiology enabled surgeons to plan and perform surgery in a modern sense. Most procedures recommended by ancient authors would be termed nonsurgical or conservative today. Ancient authors often included a discussion of compound fractures of the humerus, suggesting these injuries were a major concern.

However, historical sources based on ancient populations should be interpreted cautiously. The expected length of life among ancient Egyptians in the Dynastic Period was approximately 36 years [15] and the onset of menopause and pattern of bone loss were likely different [1]. Tools and weapons, for example, maces and battle-axes in stone and copper, may have caused a different clinical picture at the time of *The Edwin Smith Papyrus* [25]. High-speed injuries were unknown. Moreover, the available anatomic knowledge may have posed some limitations for providing multifaceted treatments and precise pathoanatomic analyses of fractures, dislocations, fracture-dislocations, and soft tissue injuries of the shoulder and upper arm.

In this study, I review the most important written contributions from Ancient Egypt, Greece, and Rome. Illustrations of reduction procedures and bandaging from surgical texts from the sixteenth and seventeenth centuries are included and possible complications are discussed.

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Ancient Egypt

The Edwin Smith Papyrus (copied circa 1600 BC)

An impressive vocabulary of approximately 250 anatomic terms has been extracted from surviving Ancient Egyptian medical texts [11, 12, 30]. In the shoulder region, the scapula and the clavicle were named separately. The scapula was named the “razor-bone,” suggesting to the Egyptians the shape of a razor. The coracoid process and spina scapulae were known as “the two-toed claw” or “the fork of the shoulder,” but they were not considered part of the scapula. Rather, they were considered part of the broader category of “the shoulder.” Nothing is said about the muscles of the shoulder and upper arm, and no distinction between nerves, tendons, and blood vessels is found.

In the earliest known surgical text, *The Edwin Smith Papyrus* (Fig. 1) [2, 4], three cases of humeral fractures appear. (Weblinks are available in Appendix 1.)

The papyrus contains 48 cases of wounds and fractures topographically ordered from the skull to the chest and upper arm. The papyrus is incomplete and fractures of the humerus are the only limb fractures dealt with. It is not known whether the text is a personal record of cases, a manual for practice, or part of a complete survey of traumatology. The cases are ordered by anatomic region, the structures affected (bone, soft tissue, or both), the severity of the injury, and recommended treatment. Four different names for fractures are found in the papyrus, suggesting a differentiated approach to skeletal injuries [4, 18].



Fig. 1 Columns XII and XIII of *The Edwin Smith Papyrus* are shown. (Courtesy of The New York Academy of Medicine Library, New York, NY.)

Case thirty-six, “A broken upper arm,” deals with the diagnosis, reduction, and bandaging of a fracture of the humerus. The prognosis of the injury is considered to be favorable. Reduction by traction is recommended: “Then you lay him out, with something folded between his shoulder blades. You have to pull his arms to lengthen his upper arms, until that break falls into its place” [2].

The same procedure of reduction is recommended for fractures of the clavicle. After reduction, the fractured humerus is bandaged with two strips of cloth with alum. The bandage is changed every day and honey is applied until recovery.

Case thirty-seven, “A broken upper arm with a wound,” deals with a compound fracture of the humerus. Two kinds of injuries are distinguished according to the depth of the lesion. The examination of the injury is done with the fingers in the wound. The case introduces the technical term *nekhebkheb* referring to a movement of the fracture under the fingers of the physician, which has been translated to “wiggling” [2] or “crepitating” [4]. If the wound is only superficial, two strips of cloth with alum, oil, and honey are applied. If bone penetrates the soft tissue and blood is issuing from the wound, the prognosis is considered hopeless and no treatment can be provided.

Case thirty-eight, “A fractured upper arm,” is the shortest of the entire papyrus. It deals with a simple fracture of the humerus with lateral soft tissue swelling but without shortening. The prognosis of this injury is considered favorable. Again the patient should be bandaged with cloth, alum, and honey.

The considerations on compound fractures point toward mechanisms of injury other than those known in orthopaedic practice today. Warfare activities and major building projects involving tools and weapons of copper and stone may have inflicted injuries with excessive soft tissue damage. Case forty-seven, “A gaping wound above the shoulder blade,” supports this assumption and points toward the risk of wounds of the shoulder becoming inflamed. Several ancient authors, including later Greek-Roman authors, explicitly deal with compound fractures of the humerus, suggesting these lesions were a major concern during antiquity.

Skeletal material from Ancient Egypt generally has a high standard of preservation, and several healed fractures of the humerus have been found (Fig. 2) [3, 17, 28]. However, the results of the recommended treatments have not been documented, as no humeral fractures with bandages in situ have been found. Findings of fractured forearms with splints in situ [26] and postmortem splinting [27] may serve to illustrate the bandaging and splinting technique recommended in *The Edwin Smith Papyrus*.

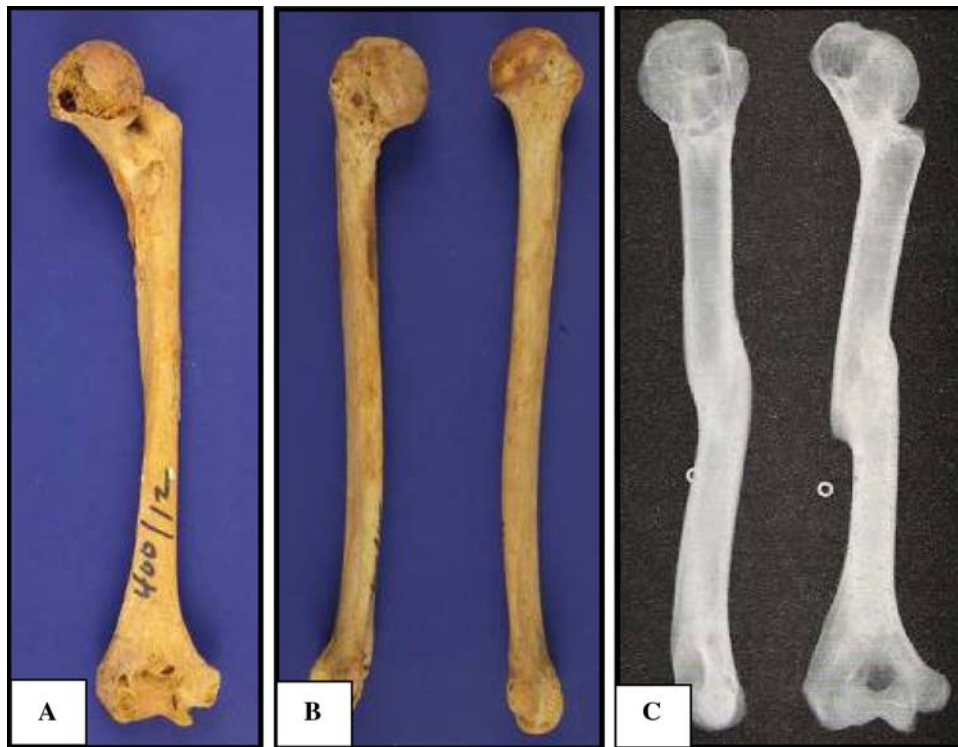


Fig. 2A–C (A) A proximal fracture of the left humerus (posterior view) is shown, which healed with considerable displacement. The humerus is from a young woman found in Egyptian Nubia in the first or middle part of New Kingdom (circa 1539–1075 BC). (Courtesy of Laboratory of Biological Anthropology, University of Copenhagen. Photograph by K. Stub. Reprinted with permission.) (B) A proximal fracture of the right humerus (lateral view) is shown, which healed with angular and rotational displacement. The humerus, from a young woman, is shortened approximately 2 cm and was found in Egyptian

Nubia during the first or middle part of New Kingdom (circa 1539–1075 BC). (Courtesy of Laboratory of Biological Anthropology, University of Copenhagen. Photograph by K. Stub. Reprinted with permission.) (C) Anteroposterior and lateral radiographs of a right humerus with healed fractures of the shaft and proximal part of the humerus found in Qau (circa 1400 BC) are shown. (Reprinted from Bourke JB. Trauma and degenerative diseases in ancient Egypt and Nubia. *J Hum Evol.* 1972;1:225–232 [3], with permission from Elsevier.)

Greek-Roman Antiquity

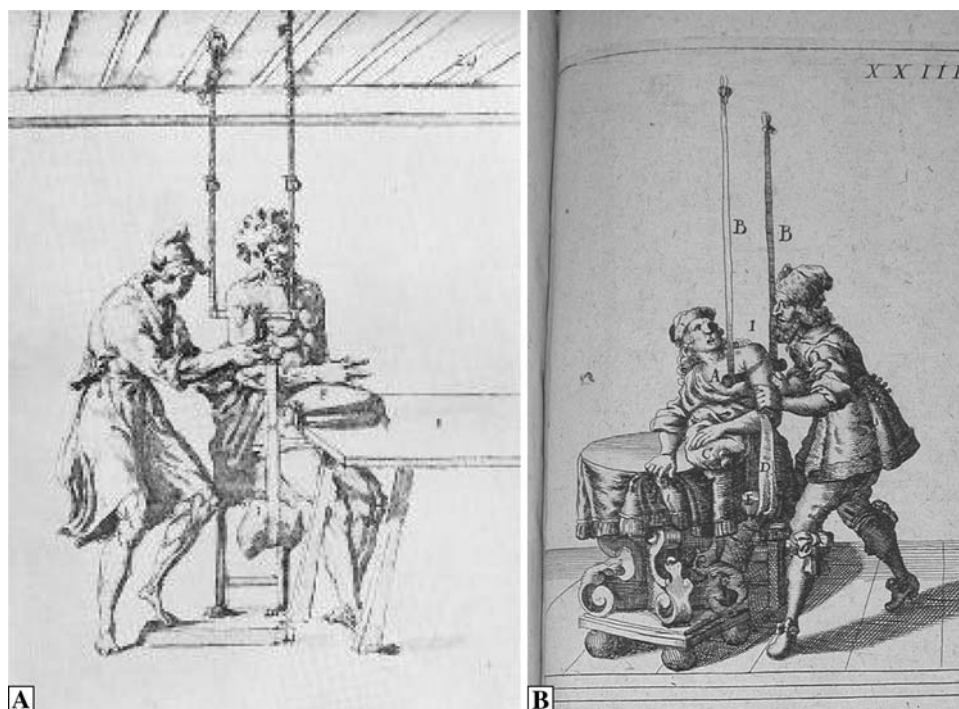
The Hippocratic Corpus (circa 440–340 BC)

The Hippocratic Corpus is a collection of about 70 works in Greek dealing with most aspects of medicine. (Weblinks are available in Appendix 1.) Some of the works have been attributed to the historic Hippocrates [circa 460–377 BC], but the question of authorship remains controversial. *The Hippocratic Corpus* was first compiled at the famous library *Museion* in Alexandria in approximately 250 BC.

The Hippocratic method of reduction of glenohumeral dislocations is known to most physicians. However, the Hippocratic approach to fractures of the humerus in *De Fracturis* (written circa 415 BC) [13] has not been studied since the early nineteenth century. The author distinguishes prognostically between proximal and distal fractures of the humerus: “Sometimes the actual head of the humerus is fractured at the epiphysis, but this, though apparently a very grave lesion, is much milder than injuries of the elbow joint” (*De Fracturis*, XLVI).

The Hippocratic mode of reduction for fractures of the humerus (*De Fracturis*, VIII) has been interpreted and illustrated in later surgical texts (Fig. 3): The patient is seated on a high stool with a hanging rod in the armpit so he can hardly sit. The patient’s elbow is flexed with a scarf with heavy weights under the forearm extending the upper arm. The physician then reduces the fracture manually. After reduction, bandages of linen are applied with the head of the bandages on the fracture. The bandages are soaked in cerate, an ointment of oil or fat mixed with wax or resin. The bandages should be changed every third day and replaced with increasing pressure. Stable fixation of the fracture may have been maintained by the bandages soaked in cerate [16]. On the seventh or ninth day, the bandage is removed and the upper arm is washed in hot water. The bandage is reapplied and splints are added. A strict diet is prescribed and the fracture is expected to heal within 40 days. The author is aware of the risk of varus displacement: “...humerus is naturally convex outwards, and is therefore apt to get distorted in this direction when improperly treated” (*De Fracturis*, VIII). In such cases, the

Fig. 3A–B Interpretations of the Hippocratic mode of reduction for fractures of the humerus (*De Fracturis*, VIII) [10] are shown. (Reprinted from (A) Primatice (1504–1570) [23], with permission from Bibliothèque nationale de France, Paris, France), and (B) Joannis Scultetus (1595–1645) [24]. (With permission from the John Martin Rare Book Room, University of Iowa, Iowa City, IA.)



humerus should be fixed with bands to the chest in valgus position after applying many-folded compresses under the elbow.

Compound fractures of the humerus are described as having a poor prognosis although methods of reduction and removal of sequestra are described. Compound fractures of the humerus are distinguished prognostically according to whether the bone protrudes on the inner or the outer side of upper arm: "...many important blood vessels stretch along the inner side, and lesions of some of them are fatal; there are also some on the outside, but fewer" (*De Fracturis*, XXXV).

The Alexandrian School of Medicine (third century BC)

Oribasius [AD 325–397] was a Byzantine medical writer and compiler born in Pergamon (in what is now the northwest part of Anatolia or the Asian portion of modern Turkey). He was a physician to Julian the Apostate Emperor and studied medicine in Alexandria. He was a mediator of earlier medical writings not found elsewhere. Only 25 of the approximately 70 original books in *Oribasii Collectiones Medicae* have survived.

No primary sources survived the great fires of the Alexandrian library *Museion*, and *The Alexandrian School of Medicine* is mainly known through later Roman compilers. Thus, Oribasius refers to an Alexandrian discussion on the treatment of shoulder dislocations complicated by a fracture of the humerus. According to Oribasius, Pasicrates

recommended setting the joint first while Heliodorus emphasized initial reduction of the fracture. Aristion treated both injuries at the same time by placing a wedge in the patient's armpit to keep the humeral head in position when reducing the fracture. Oribasius recommended reducing the dislocation before setting the fracture (*Oribasii Collectiones Medicae*, XLIX) [9, 20]. In *De Machinamentis*, Oribasius recommended using the Hippocratic bench *scamnum* for reduction of fractures and dislocations of the shoulder and upper arm (Fig. 4).

Celsus (25 BC–AD 50)

Celsus was a Roman compiler. His medical writings in Latin are collected in eight books entitled *De Medicina* [5, 6]. They are the only surviving part of a large encyclopedia also dealing with agriculture, law, rhetoric, philosophy, and military arts. *De Medicina* was first printed in 1478 and had a major impact on medical writing and practice from Roman antiquity until the late nineteenth century. (Web-links are available in Appendix 1.) It is the first surviving medical text written in Latin. Book VIII deals with fractures and dislocations, expanding on the Hippocratic approach. The description of the four cardinal signs of inflammation usually is attributed to Celsus.

Celsus distinguished between shaft fractures, proximal fractures, and distal fractures according to prognosis and treatment recommendations: "...there is least danger when the middle of the bone is fractured. The nearer the fracture



Fig. 4 An illustration of Oribasius' mode of reduction for humeral fractures and glenohumeral dislocation using the Hippocratic bench, *scamnum*, is shown. (Reprinted from Vidius [29] and Brockbank W. The man who was Vidius. *Ann R Coll Surg Engl.* 1956;19:269–295, with permission from the Royal College of Surgeons of England, London, UK.)

is to either the upper or the lower end the worse it is; for they are at once more painful and more difficult to treat" (*De Medicina*, VIII, 10).

Celsus described various fracture configurations, including transverse-, oblique-, and multifragmented fractures. He mentioned displacement of oblique fractures with abbreviation and described the sensation of crepitus: "If the fragments are in contact, they make a sound when moved and produce a stabbing sensation..." (*De Medicina*, VIII, 10).

According to Celsus, fractures of the humerus should be reduced immediately to prevent inflammation. The reduction is successful if the pain disappears and the arms become equal in length. The Hippocratic method of reduction is followed except for the use of bandage loops for extension (*De Medicina*, VIII, 10). As in *Corpus Hippocraticum*, Celsus prescribed successive application of bandages at the seventh or ninth day followed by splinting. When the proximal part of the humerus is broken, the

bandages should be longer than if the shaft or distal part is broken. If the fracture is close to the shoulder, the skin should be fomented with hot water and wine and oil should be dropped on it. To prevent gangrene, Celsus recommended making the turns of the bandage numerous rather than tight. If the fracture is not in position, it could be reduced again on the seventh or ninth day. The splints should be tightened every third day and used for $\frac{2}{3}$ of the time of healing (40 days in total). Celsus differed from Hippocrates in using six bandages instead of three; he applied larger pieces of linen and soaked it with wine and oil instead of cerate.

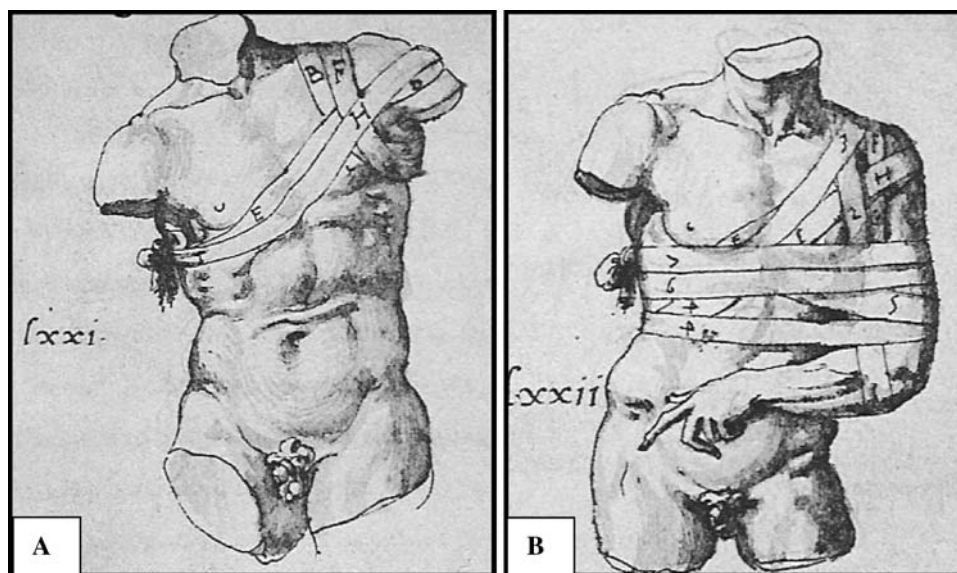
Galen (AD 129 to circa 215)

Galen was Greek physician and medical writer born in Pergamon. He traveled and studied in Greece and Egypt and was physician to the Emperor Marcus Aurelius. His anatomic works include descriptions of the spinal cord and the cranial nerves. Galen had access to fractures, dislocations, and wounds as physician to the gladiators. His experience as a surgeon is debated. Only approximately 20 of Galen's medical works survived the great fires of the Alexandrian library and they have been preserved through Arab translations. The surviving Galenic texts were collected and translated into Latin in 1821 to 1830 [10]. Galenism remained highly influential until the nineteenth century.

The ancient authors seem to have been quite familiar with bone anatomy. There is evidence that Galen spent at least 4 years in Alexandria where human dissections were practiced [19]: "For whom cannot succeed [in going to Alexandria] it is, however, not impossible to get access to human bones. At least, I have very often seen human bones owing to the dilapidation of graves or memorials" (*Opera Omnia*, II, 221-2 K, translated by K. Jungersen) [10]. Other sources for studies of human bone anatomy may have included casualties in battlefields and victims from occupational accidents. An accurate description of the humerus is found in Galen's *De ossibus ad tirones* (circa AD 180): "The humerus, the largest bone except for the femur, articulates at both ends. At the shoulder end it has an epiphysis with a very large head on a small neck. A broad fossa in the front divides the entire head into two condyles...the humerus is bowed, yet not sharply and even not uniformly; because it is convex anteriorly and outwardly and concave in the reverse" (*De ossibus ad tirones*, 16, translated by K. Jungersen).

Comments on the Hippocratic approach can be found in several Greek and Roman surgical texts. In Galen's *In Hippocratis librum de fracturis commentarii*, a detailed account of the Hippocratic approach is given, including

Fig. 5A–B (A) The *spica simplex* is recommended by Galen in *De Fasciis* (*Opera Omnia*, XVIII A, 768–827) [10] after reduction of proximal humeral fractures, shoulder dislocations, and fractures of the clavicle. (Reprinted from Galen [10], with permission from Bibliothèque nationale de France, Paris, France.) (B) By application of an additional bandage around the breast after placing compresses under the elbow, a valgus pressure can be obtained. (Reprinted from Primatic [23], with permission from Bibliothèque nationale de France, Paris, France.)



instructions on how to restore “the natural configuration” of the humerus, reduce the fractured humerus by extension, bring together the broken bones, keep the reduction, and apply the bandage (*Opera Omnia*, XVIII B, 418–431).

In *De fasciis* (*Opera Omnia*, XVIII A, 768–827), Galen described application of bandages after reduction. The preferred bandage for fractures of the humeral neck, and for shoulder dislocations and fractures of the clavicle, is the *spica simplex* (Fig. 5). Galen followed Hippocrates in applying splints on the seventh or ninth day postinjury when the muscles were tiny and weak.

Paul of Aegina (circa AD 625–690)

Paul of Aegina (Aegina being one of the Saronic Islands of Greece) was a Byzantine physician and medical writer. He compiled the medical knowledge at his time in the encyclopedia *Epitome medicae libri septem* [21, 22]. (Weblinks are available in Appendix 1.) Surgical matters were discussed in the sixth book. *Epitome* was translated into Arabic in the ninth century and was widely used by Arab and Western physicians throughout the Middle Ages and the Renaissance. The first printed version appeared in 1528. An English translation was published in 1844 to 1847. Paul of Aegina contributed to the spread of the Galenic influence.

In *Epitome*, Paul of Aegina commented on the Hippocratic approach to fractures. He classified traumatic fractures into transverse fractures, longitudinal fractures, comminuted fractures, and fractures at one part straight and at its extremity lunated (*Epitome*, VI, 89).

The reduction of proximal humeral fractures was made by extension and counterextension with a thong in the

armpit pulled by an assistant. Paul recommended application of six bandages in proximal fractures of the humerus. After applying cerate on the skin, the first bandage should take in the acromion, scapula, and sternum. The second bandage is to extend to the elbow and revert to the upper part of the humerus. The bandages are secured by linen with cerate. The next bandages are applied in contrary directions to each other. The chest should be moderately bound with the arm. Opposed to the Hippocratic approach, Paul prescribed immediate application of splints. Compresses folded three times and dipped in oil are applied before application of splints. Paul emphasized the importance of avoiding splinting over the shoulder and to counter ulcers and inflammation attributable to excessive splinting on the inner side of the humerus. The splints should be smooth, even, concave, and somewhat shorter than the length of the bandages. In case of inflammation, a spare diet was recommended and the patient should lie until callus was formed (*Epitome*, VI, 99). In fracture-dislocations, Paul recommended extension and manual reduction as in simple fractures (*Epitome*, VI, 122).

Discussion

The exact diagnosis and localization of injuries of the shoulder and upper arm remain an open question in pre-radiographic sources. The interpretation of pathoanatomic descriptions into modern scientific terms like proximal fracture, shaft fracture, distal fracture, glenohumeral dislocation, or fracture-dislocation should be made cautiously. Disfigurations of the shoulder and upper arm are compatible with several pathologic conditions in the region, and some authors might have classified any condition with an

altered surface anatomy of the shoulder as a fracture. Interpretations of reported patterns of fracture anatomy also should be made cautiously.

The described reduction maneuvers may have had an effect on several traumatic conditions: proximal humeral fractures, humeral shaft fractures, distal humeral fractures, glenohumeral dislocations, fracture-dislocations, and even fractures or dislocations of the clavicle. The question regarding the exact composition and application of bandages for humeral fractures remains unanswered, as no fractured humeral bones with bandages in situ have been found.

Long-term results of orthopaedic treatments were not systematically recorded until the late eighteenth century when pathoanatomic findings from autopsy began to be compared with clinical observations. Among the pioneers in bone pathology were Pierre-Joseph Desault (1744–1795) [8] and Astley Cooper (1768–1841) [7].

Several ancient authors were aware of the risk of iatrogenic damage during reduction and bandaging of humeral fractures. In *De Fracturis*, XXVI [13], the author refers to “...cases of fracture which are at first without wound, but where one occurs during treatment either through too great compression by bandages or the pressure of a splint or some other causes.” According to Celsus, “it is better to make the turns of the bandage numerous rather than tight, for a part which is constricted is damaged and disposed to gangrene...” (*De Medicina*, VIII, 10) [5, 6]. According to Paul of Aegina, the practitioner should take care “...that the splints do not come in contact with a joint and being more particularly careful of the inner part of the joint, for there they sometimes occasion ulcers and inflammations of tendons” (*Epitome*, VI, 99) [21, 22].

Finally, it is not known if the written sources reflect common ancient practice or were accessible to the learned elite only. It was not uncommon among ancient authors to describe ingenious procedures never performed [14]. However, many procedures undoubtedly were performed by various sorts of practitioners that were either never described or the descriptions lost. It is plausible some of these approaches were successful in restoring function. Although the written sources do not attest to the actual use of the procedures and mechanical devices described, they document a diversity of approaches to diagnosis, reduction, and bandaging of humeral fractures considered by learned physicians in Ancient Egypt, Greece, and Rome. Future comparative studies of written sources and human remains may elucidate the actual ancient management of humeral fractures.

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Appendix 1. Weblinks to Texts

1. The full-text version of Breasted's translation (1930) of Edwin Smith Papyrus is available at: <http://www.touregypt.net/edwinsmithsurgical.htm> or <http://web.archive.org/web/20040404135933/www.eoa.org/edwintxt.htm> (Last updated March 2004)
2. The full text version of Francis Adams' translation of Hippocrates' 'On fractures' is available at http://www.greektexts.com/library/Hippocrates/On_Fractures/eng/index.html
3. Celsus' 'De Medicina' in Spencer's translation from 1935 is available at http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Celsus/8*.html
4. Paul of Aegina's 'Epitome' in Francis Adams' translation from 1844-7 can be downloaded in facsimile from: <http://web2.bium.univ-paris5.fr/livanc/?p=465&cote=37321x02&do=page>

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